Center for Teaching Old Models New Tricks (TOMNET)

A USDOT Tier 1 University Transportation Center

PROJECT PROPOSAL 2019-2020

Title: Attitudes and Behaviors Causal Relationships: Uncovering Latent Segments within a Heterogeneous Population

Principal Investigator: Ram Pendyala, Professor, School of Sustainable Engineering and the Built Environment, Arizona State University

Co-Principal Investigator: Sara Khoeini, Assistant Research Professor, School of Sustainable Engineering and the Built Environment, Arizona State University

1. Introduction/Problem Statement

This project is concerned with exploring the relationship between attitudes, perceptions, and values on the one hand and behavioral choices on the other hand. There is a vast body of literature in a number of disciplines that has clearly demonstrated a strong inter-dependent relationship between attitudes and behaviors (Wicker, 1969; Norman, 1975; Fishbein and Ajzen, 2010; Ahn and Back, 2018). In the transportation context, attitudes about various transportation options as well as personality traits that describe the innate proclivities and preferences of the individual are likely to be strongly associated with residential and work place location choices (Cao et al., 2010; Bhat, 2015a, Ettema and Nieuwenhuis, 2017), mode choice (Heinen et al., 2011; He and Thøgersen, 2017), parking choice (Soto et al., 2018), vehicle ownership and type choice (Acker et al., 2014; Choo and Mokhtarian, 2004), activity engagement and time use patterns (Archer et al., 2013; Frei et al., 2015), and willingness to participate in the sharing economy and adopt new technologies (Astroza et al., 2017; Lavieri et al., 2018; Egbue and Long, 2012; Alemi et al., 2018).

The question that motivates this research is: Do "attitudes affect behavioral choices" or "do experiences obtained through the exercise of behavioral choices shape attitudes"? A number of studies have utilized attitudinal variables and factors as explanatory variables to explain travel choices and behaviors (Ory and Mokhtarian, 2005; Seraj et al., 2012; Heinen et al., 2013; Bhat et al., 2016; Chen et al., 2017). These variables are combined with the usual socio-economic and demographic variables, built environment variables, and variables that describe the options in the choice set to predict behaviors. In most, if not all instances, these studies have reported that attitudinal variables contribute significantly to explaining the choice behaviors of interest.

More recently, however, a growing body of literature reports that the directionality of the relationship between attitudes and behaviors is actually one in which behaviors shape attitudes (Kroesen et al., 2017; Kroesen and Chorus, 2018). According to these studies, contrary to assumptions embedded in most models, behavior influences attitudes. These studies suggest that, when there is dissonance (inconsistency) between attitudes and behaviors, people are more prone to adjust their attitudes to align with behaviors as opposed to adjusting their behaviors to align with attitudes.

While attitudes and behaviors mutually influence each other over time (Kroesen et al., 2017), and attitudes themselves may change as more information becomes available (Sheela and Mannering, 2019), the question as to whether *attitudes affect behaviors* or *behaviors affect attitudes* at any point in time remains an intriguing one with very important implications for transportation demand forecasting and the

design and implementation of policy interventions aimed at shaping behaviors. If it is true that behaviors affect attitudes (rather than the reverse), then information campaigns and strategies aimed at reshaping attitudes may not have the desired and intended effects. Policy interventions would need to directly target behavioral choices by providing individuals the opportunities to obtain alternative experiences first-hand by actually trying new and different mobility options; alternative behavioral experiences would then bring about changes in attitudes that would further reinforce desirable behaviors as individuals adjust their attitudes to reduce dissonance (Kroesen et al., 2017).

2. Project Objectives

This study aims to develop a joint equations model of attitudes and behaviors that explicitly recognizes the package nature of the relationship among them. However, unlike previous studies, this research effort explicitly recognizes that there may be population heterogeneity with respect to the nature of the relationship between attitudes and behaviors. While undoubtedly mutually reinforcing, attitudes may influence behaviors for some folks and behavioral choices may affect attitudes for others *at a specific cross-section in time*. A multitude of directional relationships between attitudes and behaviors may exist in the population and it would be of interest to determine the extent or degree to which each of the directional relationships is prevalent in the population *at a specific cross-section in time*. By determining the degree to which each relationship exists in the population, and the characteristics of each market segment (in terms of socio-economic and demographic characteristics, for example), it would be possible to design policy interventions, behavioral experiences, and information campaigns that are appropriately targeted and implemented to achieve desired outcomes.

3. Proposed Methodology and Data

The model system in this study will be estimated on a data set derived from the 2014 Who's On Board Mobility Attitudes Survey conducted in the United States. In addition to an extensive battery of attitudinal variables, the survey includes information about people's behavioral choices including use of various modes of transportation, residential location type choice, and car ownership. This particular study examines the nature of the relationships between *attitudes toward transit* and two behavioral choice variables, namely, *residential location choice* and *frequency of use of transit*. By considering multiple behavioral dimensions, this study sheds light on the extent to which attitudes affect behavior (or vice versa) in the context of different behavioral choices and identifies the relative presence of different latent segments (following different decision structures) in the population.

While previous literature has often characterized a uni-directional relationship between attitudes and behaviors, there is significant evidence of the existence of a bi-directional relationship as well (Dobson et al., 1978, Kroesen et al., 2017; Kroesen and Chorus, 2018). This study treats both attitudinal variables and behavioral choice variables as endogenous in nature, thus recognizing endogeneity associated with estimating relationships between these dimensions of interest. Treating both attitudes and behaviors as endogenous variables requires the specification and estimation of joint equations model systems that accommodate error correlations, making it possible to account for the presence of correlated unobserved attributes that simultaneously affect both attitudes and behaviors. Because the segments in the population are not known a priori, they are considered latent and determined endogenously within a joint modeling framework. Thus, the model estimated in this study takes the form of a joint equations model system with latent segmentation, similar to that presented in Astroza et al. (2018). The model system includes a model component that endogenously assigns individuals to different causal segments, and this component is coupled with a simultaneous equations model component that relates attitudes and behaviors to one another in a manner consistent with the latent segment to which the behavioral unit has been probabilistically assigned. This methodology makes it possible to identify the characteristics of the subgroups that predominantly depict alternative causal structures.

4. Work Plan (Project Tasks)

Task 1: Literature Review, and Data Assembly
During this task, a comprehensive review of the literature on attitudes and behaviors causal relationships will be conducted. Furthermore, the study dataset from "Who's on board?" survey will be assembled with the right sample size and list of variables in SPSS.

Task 2: Estimation of Joint Model of Behavioral Choices and Attitudinal Factor and Segmentation Model
During this task, a joint equations model that relates residential location choice, frequency of transit use, and attitudes towards transit will be estimated. The former two variables constitute behaviors, while the third variable is an attitudinal factor score. The model system is estimated on a large sample data set that includes both attitudinal and behavioral choice variables. Four different latent segments are considered; two latent segments in which attitudes affect choice behaviors and two segments in which choice behaviors affect latent segments.

Task 3: Explanatory Analysis of the Results
The supplementary statistical analysis will be conducted in this step to clearly and quantitatively explain the latent segments in the population. It is hypothesized that different segments in the population follow different causal structures in their contemporaneous decision-making processes. This task estimates the size and characteristics of the latent segments to determine the extent to which behaviors affect attitudes or attitudes affect behaviors in the survey sample of this study.

Task 4: Project Deliverables
The project deliverables, including the research report, conference and journal papers, will be prepared in this step.

5. Project Schedule
Table 1 illustrates the timeline for all the tasks explained in the previous section.

TABLE 1 Project Schedule

Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
	Task 1										
				Task 2							
							Task 3				
										Task 4	

6. Relevance to the Center Theme/Mission
TOMNET whole mission is to enhance and improve the existing travel demand and behavior models by introducing the new sets of variables and methods. In terms of variables, the most promising sets of variables that have shown significant evidence to improve travel demand models are attitudes. This project goal is unraveling the contemporaneous relationship that exists between attitudes and choice behaviors. Attitudes, perceptions, and preferences may shape behaviors; likewise, behavioral choices exercised by individuals may offer experiences that shape attitudes. While it is likely that these relationships play out over time, the question whether attitudes affect behaviors or behaviors affect attitudes at a specific cross-section in time remains unanswered and a fruitful area of inquiry. Various studies in the literature have explored this question, but have done so without explicitly recognizing the heterogeneity that may exist in the population. In other words, the causal structure at play at any point in time may differ across individuals,

thus motivating the development of an approach that can account for the presence of multiple segments in the population, each following a different causal structure.

7. Anticipated Outcomes and Deliverables

It is anticipated that this project sheds light on the causal relationships between attitudes and behavior across heterogenous segments of the population. If it turns out that for the majority groups of population behaviors shape the attitudes, travel demand forecasting models that assume impact of attitudes on behavior across the entire population are likely to return erroneous predictions of travel demand in response to policy and investment scenarios. The output of this project can be used to probabilistically assign individuals in a population to different causal segments, and then forecast travel demand for different segments according to the causal structure that drives their decision-making process. From a transportation policy perspective, it would appear that information campaigns and advertisements may be effective in a world where the majority of the population has their attitudes shaped by behaviors. However, if this turns out to be not the case for the majority of the population, it becomes necessary to run campaigns where individuals actually get to experience modal options and different products first-hand; people need to be able to exercise alternative behavioral choices, learn through experience, and re-shape their attitudes in response to the experiences. The findings of this study help to make different campaigns work most effectively by targeting the appropriate segments depending on the causal structures that they follow. Additionally, the findings of this study will be published in the research report, conference and journal papers for the community enrichment.

8. Research Team and Management Plan

The research team is led by Dr. Ram Pendyala, who will serve as the Principal Investigator for the project at ASU. Sara Khoeini will serve as the co-principal investigator for the project. The project will support one highly qualified Ph.D. student completely, and a few graduate research assistants (who will assist with different data assembly and model estimation practices) partially.

Ram M. Pendyala is a Professor of Transportation Systems in the School of Sustainable Engineering and the Built Environment at Arizona State University. He serves as the Director of TOMNET. Pendyala is an expert in activity-travel behavior modeling and has led the development of a number of large scale behaviorally robust microsimulation model systems. He has published extensively in the literature and serves as the Chair of the Transportation Research Board's Planning and Environment Group (2015-2018). He previously served as Chair of the Travel Analysis Methods Section (2009-2015) as well as the Traveler Behavior and Values Committee (2003-2009). He has also served as the Chair of the International Association for Travel Behavior Research (IATBR). He is currently an Associate Editor for Transportation Research Part D. He has his Ph.D. and MS degrees in Civil and Environmental Engineering with a specialization in transportation from the University of California at Davis, and his Bachelor's degree in Civil Engineering from the Indian Institute of Technology-Madras in India.

Sara Khoeini is an Assistant Research Professor of Transportation Systems in the School of Sustainable Engineering and the Built Environment at Arizona State University. She is the Assistant Director of TOMNET. Sara has extensive experience in the study of traveler behavior and attitudes, particularly in the context of managed lane operations. She has deep expertise in statistical analysis of transportation data and travel behavior modeling. She has conducted special-purpose surveys to collect information about changes in travel behavior in response to changes in transportation system conditions. She has published her work in a variety of journals and has been active in several professional organizations. Sara has her Ph.D. from the Georgia Institute of Technology, MS from Clemson University, and her undergraduate degree from K.N.T. The University of Technology in Iran.

Ram Pendyala will be the primary point of contact for all aspects related to this research and will manage all aspects of the project. He will work closely with graduate students to accomplish the project tasks. Sara Khoeini will assist with various project tasks and provide significant input on the analytical and modeling work of the project.

9. Technology Transfer Plan

The project team believes in executing an effective technology transfer plan by disseminating project information and results widely to the professional community. During the one-year duration of this particular project, each milestone will be disseminated using one of the TOMNET communication mechanisms (e.g., website, webinar, seminar, teleconference). Project team members will prepare articles for publication in refereed journals and conference proceedings. Project team members will participate in conferences and deliver presentations about this work and the outcomes of the effort.

10. Workforce Development and Outreach Plan

The project incorporates a strong workforce development and outreach plan. The project will employ a full-time Ph.D. graduate student as a graduate research associate. The doctoral student will be involved in all aspects of the project including literature review, data assembly, and model estimation. At ASU, project team members will engage with the National Summer Transportation Institute, a three-week residential summer program for high school students that aims to expose them to transportation-related careers. Finally, the project will also welcome high school students who may be interested in serving as volunteer researchers under the TOMNET Scholar Initiative. Findings from the project will be integrated into graduate-level courses taught at various institutions in the consortium so that the research and workforce development activities of the center are seamlessly blended together.

11. References

Acker, V., Mokhtarian, P.L., & Witlox, F. (2014). Car availability explained by the structural relationships between lifestyles, residential location, and underlying residential and travel attitudes. *Transport Policy, 35*, 88–99.

Ahn, J., & Back, K-J. (2018). Influence of brand relationship on customer attitude toward integrated resort brands: a cognitive, affective, and conative perspective. *Journal of Travel & Tourism Marketing, 35*(4), 449–460.

Alemi, F., Circella, G., Handy, S.L., & Mokhtarian, P.L. (2018). What influences travelers to use Uber? Exploring the factors affecting the adoption of on-demand ride services in California. *Travel Behaviour and Society, 13*, 88–104.

Archer, M., Paleti, R., Konduri, K.C., Pendyala, R.M., & Bhat, C.R. (2013). Modeling the connection between activity-travel patterns and subjective well-being. *Transportation Research Record, 2382*, 102–111.

Astroza, S., Garikapati, V.M., Bhat, C.R., Pendyala, R.M., Lavieri, P.S., & Dias, F.F. (2017). Analysis of the impact of technology use on multimodality and activity travel characteristics, *Transportation Research Record, 2666*, 19–28

Astroza, S., Garikapati, V.M., Pendyala, R.M., Bhat, C.R., & Mokhtarian, P.L. (2018). Representing heterogeneity in structural relationships among multiple choice variables using a latent segmentation approach. *Transportation*, forthcoming. https://doi.org/10.1007/s11116-018-9882-7.

Bhat, C.R. (2015a). A new generalized heterogeneous data model (GHDM) to jointly model mixed types of dependent variables. *Transportation Research Part B, 79*, 50–77.

Bhat, C.R., Astroza, S., Bhat, A.C., & Nagel, K. (2016). Incorporating a multiple discrete-continuous outcome in the generalized heterogeneous data model: Application to residential self-selection effects analysis in an activity time-use behavior model, *Transportation Research Part B, 91*, 52–76

Cao, X.J., Xu, Z., & Fan, Y. (2010). Exploring the connections among residential location, self-selection, and driving: Propensity score matching with multiple treatments. *Transportation Research Part A, 44*(10), 797–805.

Chen, F., Wu, J., Chen, X., & Wang, J. (2017). Vehicle kilometers traveled reduction impacts of Transit-Oriented Development: Evidence from Shanghai City. *Transportation Research Part D, 55*, 227–245.

Choo, S., & Mokhtarian, P.L. (2004). What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A, 38*(3), 201–222.

Dobson, R., Dunbar, F., Smith, C.J., Reibstein, D., & Lovelock, C. (1978). Structural models for the analysis of traveler attitude-behavior relationships. *Transportation, 7*(4), 351–363.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy, 48*, 717–729.

Ettema, D., & Nieuwenhuis, R. (2017). Residential self-selection and travel behaviour: what are the effects of attitudes, reasons for location choice and the built environment? *Journal of Transport Geography, 59*, 146–155

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. Psychology Press, Taylor & Francis Group, New York, NY.

Frei, C., Mahmassani, H.S., Frei, A. 2015. Making time count: Traveler activity engagement on urban transit. *Transportation Research Part A* 76, 58–70.

He, S.Y., & Thøgersen, J., (2017). The impact of attitudes and perceptions on travel mode choice and car ownership in a Chinese megacity: The case of Guangzhou. *Research in Transportation Economics, 62*, 57–67.

Heinen, E., Maat, K., & van Wee, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. *Transportation Research Part D, 16*(2), 102–109.

Heinen, E., Maat, K., & van Wee, B. (2013). The effect of work-related factors on the bicycle commute mode choice in the Netherlands. *Transportation, 40*(1), 23–43.

Kroesen, M., Handy, S.L., & Chorus, C. (2017). Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modeling. *Transportation Research Part A, 101*, 190–202.

Kroesen, M., & Chorus, C. (2018). The role of general and specific attitudes in predicting travel behavior – A fatal dilemma? *Travel Behaviour and Society, 10*, 33–41.

Lavieri, P.S., Dai, Q., & Bhat, C.R. (2018). Using virtual accessibility and physical accessibility as joint predictors of activity-travel behavior. *Transportation Research Part A, 118*, 527–544.

Norman, R. (1975). Affective-cognitive consistency, attitudes, conformity, and behavior. *Journal of Personality and Social Psychology, 32*(1), 83–91.

Ory, D.T., & Mokhtarian, P.L. (2005). When is getting there half the fun? Modeling the liking for travel. *Transportation Research Part A,* 39(2-3), 97–123.

Seraj, S., Sidharthan, R., Bhat, C.R., Pendyala, R.M., & Goulias, K.G. (2012). Parental attitudes toward children walking and bicycling to school: multivariate ordered response analysis. *Transportation Research Record, 2323*, 46–55.

Sheela, P., & Mannering, F. (2019). The effect of information on changing opinions toward autonomous vehicle adoption: An exploratory analysis. *International Journal of Sustainable Transportation*, forthcoming.

Soto, J.J., Márquez, L., & Macea, L.F. (2018). Accounting for attitudes on parking choice: An integrated choice and latent variable approach. *Transportation Research Part A* 111, 65-77.

Transit Center. (2014). *Who's On Board: 2014 Mobility Attitudes Survey*. Transit Center, New York, NY.

Wicker, A.W. (1969). Attitudes versus actions: The relationship of verbal and overt behavioral responses to attitude objects. *Journal of Social Issues, 25*(4), 41–78.

12. Qualifications of Investigators (One-page CV per Investigator)

RAM M. PENDYALA

Professor, Sustainable Engineering and the Built Environment
Arizona State University (ASU), Tempe, AZ 85287-3005 Email: pendyala@asu.edu

Education
Ph.D., Civil Engineering (Transportation), University of California-Davis, December 1992.
M.S., Civil Engineering (Transportation), University of California-Davis, June 1990.
B.Tech., Civil Engineering, Indian Institute of Technology-Madras, June 1988

Employment and Professional Experience (last 25 years)
Professor, Sustainable Engineering and the Built Environment, ASU, 2006-2014 & 2016-present.
Frederick R. Dickerson Chair Professor, School of Civil and Environmental Engineering, Georgia Institute of Technology, 2014-2016
Senior Sustainability Scientist - Global Institute of Sustainability, ASU, 2011-Present.
Asst/Assoc/Professor, Civil & Environmental Engineering, Univ of South Florida, 1994-2006.
Assistant Professor, Civil Engineering, University of Louisiana at Lafayette, 1992-1994.

Fields of Interest and Expertise
(1) Multimodal transportation systems planning; (2) Activity-travel behavior analysis; (3) Transportation demand modeling and forecasting; (4) Mobility analytics and visualization; (5) Statistical and econometric analysis of transportation data; (6) Dynamic mobility management; (7) Travel survey methods and data collection; (8) Built environment – transportation – energy

5 Recent Relevant Publications (from over 200)
1. Garikapati, V. M., Pendyala, R. M., Morris, E. A., Mokhtarian, P. L., and McDonald, N. (2016). Activity Patterns, Time Use, And Travel of Millennials: A Generation in Transition? *Transport Reviews*, 36(5), pp. 558-584.
2. Pinjari, A. R., Augustin, B., Sivaraman, V., Imani, A. F., Eluru, N., and Pendyala, R. M. (2016). Stochastic Frontier Estimation of Budgets for Kuhn–Tucker Demand Systems: Application to Activity Time-Use Analysis. *Transportation Research Part A*, 88, pp. 117-133.
3. Shin, J., Bhat, C. R., You, D., Garikapati, V. M., and Pendyala, R. M. (2015). Consumer Preferences and Willingness to Pay for Advanced Vehicle Technology Options and Fuel Types. *Transportation Research Part C*, 60, pp. 511-524.
4. Garikapati, V. M., You, D., Pendyala, R. M., Jeon, K., Livshits, V., and Vovsha, P. S. (2015). Tour Characterization Framework Incorporating Activity Stop–Sequencing Model System. *Transportation Research Record: Journal of the Transportation Research Board*, 2494, pp. 77-86.
5. Archer, M., Paleti, R., Konduri, K., Pendyala, R., & Bhat, C. (2013). Modeling the connection between activity-travel patterns and subjective well-being. *Transportation Research Record: Journal of the Transportation Research Board*, 2382, pp. 102-111.

Graduate Student Supervision/Advising
Graduated: 10 PhDs (includes 2 women), 50 Masters;   **Current Supervision**: 4 PhDs

Recent Honors and Awards
Pyke Johnson Award for Best Paper in Planning and Environment, Transportation Research Board of the National Academies, 2011 and 2013
Invited Speaker, Distinguished Lecture Series, Department of Civil and Environmental Engineering, Florida International University, 2015
Invited Keynote Speaker at 5 International/National Conferences, 2014-2016

SARA KHOEINI
Assistant Research Professor, Sustainable Engineering and the Built Environment
Arizona State University (ASU), Tempe, AZ 85287-3005 Email: Sara. Khoeini@asu.edu

Education
Ph.D., Civil Engineering (Transportation), Georgia Institute of Technology, May 2014.
M.Sc., Civil Engineering (Transportation), Clemson University, Dec 2009.
B. Sc., Civil Engineering, K.N. Toosi University of Technology, Aug 2007.

Employment and Professional Experience (last 25 years)
Assistant Research Professor, Sustainable Engineering and the Built Environment, ASU, March 2017 – present

Research Affiliate, School of Civil and Environmental Engineering, Georgia Institute of Technology, April 2015 – Feb 2017

Research Scientist I, School of Civil and Environmental Engineering, Georgia Institute of Technology, March 2014 – March 2015

Fields of Interest and Expertise
(1) Urban transportation systems planning; (2) Travel behavior analysis; (3) Transportation demand modeling and forecasting; (4) Geographic Information Systems; (5) Statistical analysis of transportation data; (6) Travel survey methods and data collection; (7) Sustainability and energy

5 Recent Relevant Publications

1. **S. Khoeini**, and R. Guensler. "Socioeconomic Assessment: Conversion of I-85 High-Occupancy Vehicle to High-Occupancy Toll in Atlanta, Georgia"; Transportation Research Record: Journal of the Transportation Research Board, National Academy of Sciences; No. 2450.1, pp. 52-61, 2014.

2. **S. Khoeini**, R. Guensler. "Using Vehicle Value In place of income For Pricing Economic Analysis: A case study on Atlanta I-85 HOT lane"; Research in Transportation Economics, Special issue on "road pricing in US", Vol. 44, pp. 33-42, 2014.

3. F. Castrillon, M. Roell, **S. Khoeini**, R. Guensler. "The I-85 HOT Lane's Impact on Atlanta's Commuter Bus and Vanpool Occupancy"; Transportation Research Record Journal of the Transportation Research Board, National Academy of Sciences; No. 2470, pp. 169-177, 2014.

4. V. Elango, **S. Khoeini**, Y. Xu, R. Guensler. "Longitudinal GPS Travel Data and Breach of Privacy via Enhanced Spatial and Demographic Analysis"; Transportation Research Record: Journal of the Transportation Research Board, National Academy of Sciences; No. 2345, pp. 86-98, 2013.

5. **S. Khoeini**, R. Guensler, M. Rodgers, V. Elango. "Sensitivity of commuters' demographic characteristics to license plate data collection specifications: A case study for HOV-to-HOT project in I-85 corridor, Atlanta, GA"; Transportation Research Record: Journal of the Transportation Research Board, National Academy of Sciences; No. 2308, pp. 37-46, 2012.

Honors and Awards
Student of The Year, Georgia Tech National Center for Sustainable Transportation, 2013
WTS Helene M. Overly Memorial Scholarship, 2013
Best Student Paper Award, Freeway & Managed Lane Operations Meeting and Conference, Atlanta, GA, 2013
Ranked 2nd, Nationwide Graduate School Entrance Examination, Civil Engineering-Surveying, Iran, 2007

13. Budget Including Non-Federal Matching Funds

Institution: Arizona State University

Project Title: Attitudes and Behaviors Causal Relationships: Uncovering Latent Segments within a Heterogeneous Population

Principal Investigator: Ram Pendyala

Budget Period: 8/1/2019 - 07/31/2020

CATEGORY	Budgeted Amount from Federal Share	Budgeted Amount from Matching Funds	Explanatory Notes; Identify Source of Matching Funds
Faculty Salaries			
Other Staff Salaries			
Student Salaries			
Fringe Benefits			
Total Salaries & Benefits			
Student Tuition Remission			
Operating Services and Supplies			
Domestic Travel			
Other Direct Costs (specify)			
Other Direct Costs (specify)			
Total Direct Costs			
F&A (Indirect) Costs			
TOTAL COSTS			

Grant Deliverables and Reporting Requirements for UTC Grants (November 2016)
Exhibit F

UTC Project Information	
Project Title	Attitudes and Behaviors Causal Relationships: Uncovering Latent Segments within a Heterogeneous Population
University	Arizona State University
Principal Investigator	Ram Pendyala
PI Contact Information	
Funding Source(s) and Amounts Provided (by each agency or organization)	
Total Project Cost	
Agency ID or Contract Number	
Start and End Dates	8/1/2019 - 07/31/2020
Brief Description of Research Project	This project goal is unraveling the contemporaneous relationship that exists between attitudes and choice behaviors. Attitudes, perceptions, and preferences may shape behaviors; likewise, behavioral choices exercised by individuals may offer experiences that shape attitudes. While it is likely that these relationships play out over time, the question whether attitudes affect behaviors or behaviors affect attitudes at a specific cross-section in time remains unanswered and a fruitful area of inquiry. Various studies in the literature have explored this question, but have done so without explicitly recognizing the heterogeneity that may exist in the population. In other words, the causal structure at play at any point in time may differ across individuals, thus motivating the development of an approach that can account for the presence of multiple segments in the population, each following a different causal structure. Results suggest that there is considerable heterogeneity in the population with the contemporaneous causal structures in which behaviors shape attitudes more prevalent than those in which attitudes affect choice behaviors. These findings have important implications for transport modeling and policy development.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	It is anticipated that this project sheds light on the causal relationships between attitudes and behavior across heterogenous segments of the population. If it turns out that for the majority groups of population behaviors shape the attitudes, travel demand forecasting models that assume impact of attitudes on behavior across the entire population are likely to return erroneous predictions of travel demand in response to policy and investment scenarios. The output of this project can be used to probabilistically assign individuals in a population to different causal segments, and then forecast travel demand for different segments according to the causal structure that drives their decision-making process. From a transportation policy perspective, it would appear that information campaigns and advertisements may be effective in a world where

	the majority of the population has their attitudes shaped by behaviors. However, if this turns out to be not the case for the majority of the population, it becomes necessary to run campaigns where individuals actually get to experience modal options and different products first-hand; people need to be able to exercise alternative behavioral choices, learn through experience, and re-shape their attitudes in response to the experiences. The findings of this study help to make different campaigns work most effectively by targeting the appropriate segments depending on the causal structures that they follow. Additionally, the findings of this study will be published in the research report, conference and journal papers for the community enrichment.
Impacts/Benefits of Implementation (actual, not anticipated)	The main benefit of this project is to be able to assign heterogenous segments of the populations based on attitudes-behaviors causal segmentations. The correct segmentation of the population can be used to estimate appropriate travel demand models for each segment of the population. Furthermore, policy campaigns can also target their activities based on the characteristics of each population segments to focus on attitudes or behavior sides of issues.
Web Links • Reports • Project Website	